When the Shore becomes the Sea

van Popta, Yftinus

DOI:
10.33612/diss.135931299

5 Where are the shipwrecks of the Zuyder Zee?

A new version of the Shipwreck Database Flevoland (SDF 3.0), based on spatial and archaeohistorical research concerning wreck sites in the province of Flevoland

*Yftinus T. van Popta**

Abstract
For several decades, maritime archaeologists, authorities and maritime archaeological companies have worked with an out-of-date and inaccurate dataset (with regard to position and presence) of shipwrecks in part of the Zuyder Zee region. The information about these wrecks was scattered over several databases (both analog and digital) containing different numbers of shipwrecks in Flevoland. In order to gain a clear and accurate overview of the shipwrecks that were discovered in the former Zuyder Zee, the Shipwreck Database Flevoland (SDF) was made. The third version of the database is presented in this article and is mainly made to improve the knowledge of the present situation of shipwreck sites (wreck *in situ*, removed or unknown) and the accuracy of the coordinates that represent the location of the shipwreck (exact, estimated or unknown). The excavation documentation of the shipwrecks was used for retrieving accurate descriptions of wreck sites, although in most cases these descriptions referred to drain ditches and other local topography that have been removed or changed in time. Historical aerial photographs, LiDAR-data and satellite images were used for retrieving the locations of the relevant drain ditches and the exact locations of shipwrecks. Tens of wreck sites were discovered on the aerial photographs, either as a discoloration (disturbance) or as an excavation pit. These visible wreck locations correspond perfectly to the locations mentioned in the research reports and prove the accuracy and feasibility of the used methodology. The new version of the SDF therefore provides a more accurate distribution and density map of wreck sites in the province of Flevoland, which is of importance for spatial maritime archaeological research. Furthermore, the new information on the accuracy and presence/absence of shipwrecks can be adopted and used for archaeological heritage management purposes. Only then can the shipwrecks that are still present in the former seabed and of which the wreck location is relatively accurate be protected effectively.

Keywords
Zuyder Zee, the Netherlands, maritime archaeology, shipwrecks, spatial research, Late Middle Ages, Modern Era

Published
2018, Palaeohistoria 59/60: 191-227**

* I would like to thank prof. André van Holk for his supervision and dr. Martijn Manders and an anonymous reviewer for their useful comments.

** This chapter is a minor revision of the Palaeohistoria-article and reproduced with permission of the University of Groningen and Groninger Institute of Archaeology.

Introduction

The study of ships and especially those that have wrecked, that is nautical archaeology, is considered as the main subdiscipline of maritime archaeology (Bass 2013: 3). The maritime archaeological focus has however shifted from more or less isolated nautical studies towards interdisciplinary and spatial research in which the (maritime) landscape plays an important role. Especially the concept of the maritime cultural landscape has gained a lot of influence in maritime archaeology since it was coined by Westerdahl in the late 20th century (Westerdahl 1992; 2013). Within the boundaries of this concept, shipwrecks are still considered as major maritime features, but as part of the maritime landscape, rather than as isolated objects. The analysis of shipwreck locations in relation to the landscape can for example provide information on popular sailing routes and destinations, hazardous areas, the presence of water at a certain moment of time and therefore help to reconstruct the maritime cultural landscape. The presence of hundreds of discovered shipwrecks in this region provides information on the organization and layout of the maritime cultural landscape of the drained part of the former Zuyder Zee, today the province of Flevoland (see: Van Popta 2017a). This particular research focuses solely on the distribution of shipwrecks from the region and therefore contributes to the more broadly-based dissertation.

The Zuyder Zee, a large inland sea in the center of the Netherlands, existed from approximately AD 1200 until its partial reclamation in 1932 (Fig. 5.1). The Zuyder Zee was of great importance for the Low Countries as it was characterized by a lot of marine traffic, connecting different parts of the Netherlands with each other and to other parts of Europe. One could even state that this dense network of inland shipping, with the Zuyder Zee functioning as the main traffic circle and highway, was the basis of the Dutch 'Golden Age' (17th century; Van Holk 2005: 23). This is also reflected by the large number of shipwrecks that was found after the partial reclamation of this inland sea. Three large polders (Noordoostpolder, Eastern Flevoland and Southern Flevoland) were created and are now known as the 12th province of the Netherlands: Flevoland. Nowadays, Flevoland is famous as the 'largest ship graveyard on land' in the world. The unique situation of exploring and cultivating a former seabed provided a lot of work for the first archaeologists that worked in the polders. Especially in the early years of the Noordoostpolder, new shipwrecks were discovered almost weekly. In many cases, this was caused by the digging of parcel ditches, the laying of drainage systems (pipes) and the first ploughing of the polder. As soon as construction workers or farmers found pieces of wood (timbers) in the soil, it was almost certain that they encountered a shipwreck. The large number of discovered shipwrecks and the high work pressure caused the archaeologists to critically judge every discovery and to work selectively. Promising and relatively complete shipwrecks were completely excavated, documented and drawn in detail, while young (19th–20th century) and mainly iron-hulled shipwrecks were removed and written off without any proper documentation. Many other wrecks were, for varying reasons, briefly explored and 'reserved for future research'.

In due course, a large but very inconveniently arranged dataset was generated with information on shipwrecks in the province of Flevoland. At first, this dataset could only be consulted on paper, but most information was eventually digitalized and could therefore easier be accessed. The descriptions of shipwreck locations were transformed into modern day coordinates of the Dutch National Grid (Rijksdriehoeksstelsel, EPSG: 28992). The arrival of the digital era also resulted in the creation of the national archaeological database ARCHIS. The first version was launched in 1992 and anno 2018 archaeologists are working with version 3.0 (Wiemer 2002: 103). All available shipwreck data from the province of Flevoland was added to ARCHIS and the database is updated with new archaeological records. Research by Van Popta (2012b) has however proven that in the course of time, many errors concerning Zuyder Zee shipwrecks have sneaked into ARCHIS. This is caused on the one hand by the massive and inconveniently arranged database and on the other hand by the fact that non-specialists have entered and interpreted the data incorrectly (Van Popta 2012b: 97). For this reason, a new maritime archaeological database was created by Van Popta (2012a; 2012b; 2017b), the Shipwreck Database Flevoland (SDF), for the purpose of creating a conveniently arranged, reliable and up-to-date overview of shipwrecks in the province of Flevoland. The first two versions of this database have already been used by several archaeological companies, municipalities, provinces and archaeologists of the Dutch Cultural Heritage Agency. In this paper, the latest version of the SDF (3.0) is presented, developed and maintained by the first author.[1] The new version contains strongly improved information on the presence or absence of shipwrecks and the accuracy of shipwreck locations. The presence of shipwrecks has never thoroughly been examined as there is no overview of which shipwrecks are still present in the former seabed. The position of a wreck site also has never been checked and is of importance for spatial research (shipwreck distribution) and the protection of wreck sites. The threefold main question of this research is based on the following factors: how accurate are the locations of shipwrecks

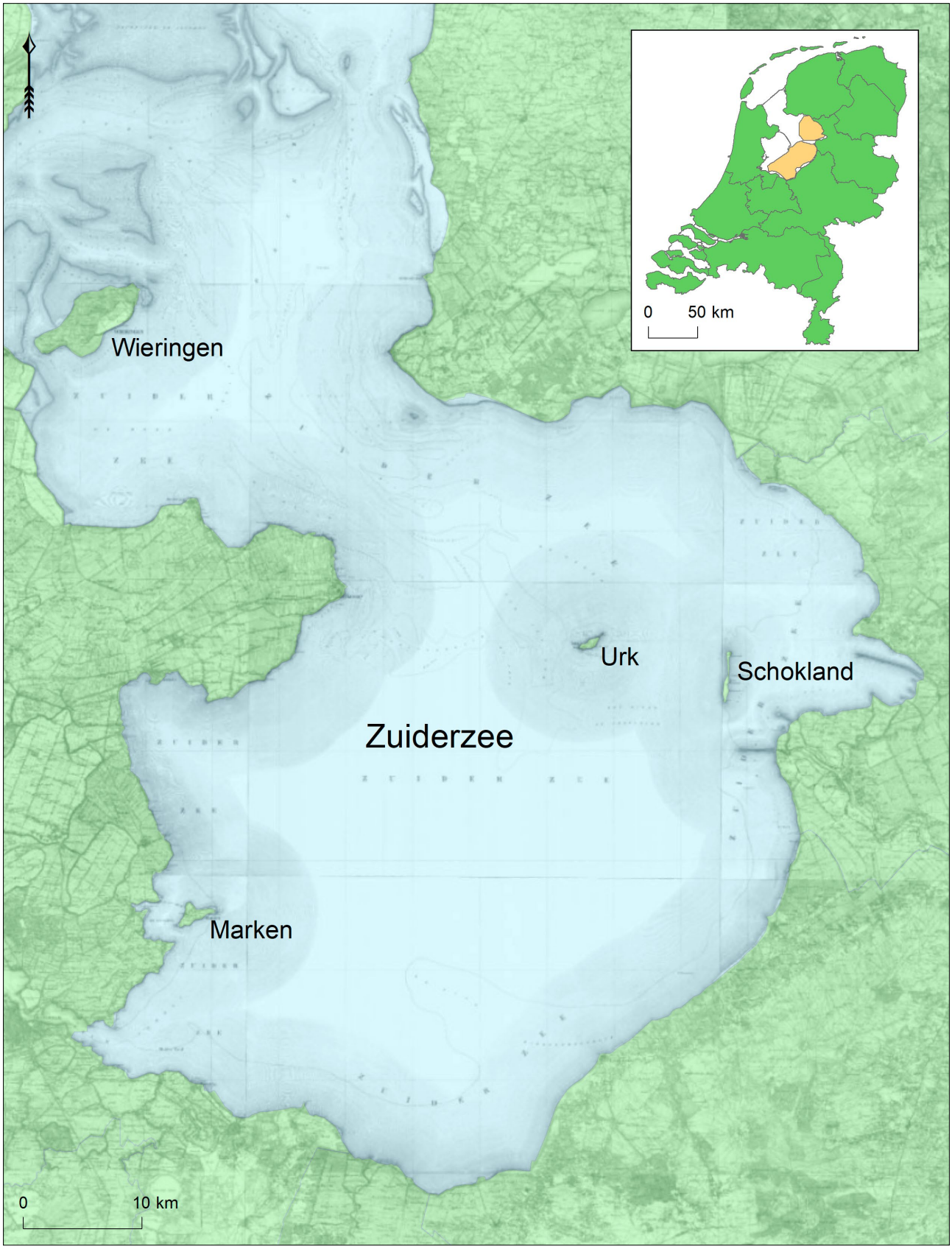


Figure 5.1. The Zuyder Zee region at the end of the 19th century. The inset depicts in orange the main research area, nowadays known as the province of Flevoland.

in Flevoland, how many shipwrecks are still present in the soil[2], and how relevant are the factors 'accuracy' and 'presence' for current maritime archaeological research in the Zuyder Zee region? The answer to these questions are of course linked to the scale of the questions asked (local, regional, national).

Previous research

Several datasets were consulted to assemble shipwreck-related information. First, all available digital scans of the shipwreck archive of Flevoland, kept by the 'Stichting Erfgoedpark Batavialand', were examined. The archive consists of thousands of pages from daily reports of shipwreck excavations, drawings, photographs (slides), wreck site descriptions, wreck site notifications, artifact inventories, correspondence, and official but unpublished archaeological reports. Together, these documents form the primary source of information on shipwrecks in the province of Flevoland. For the oldest excavations (1940s and 1950s) these are often the only available source of information. The second dataset that was used for this research is the so called Ship Catalog (*Scheepscatalogus*, latest version 2006) created by Rob Oosting and Gerard van Haaff of the Cultural Heritage Agency of the Netherlands (RCE). This database contains primary information on shipwrecks in Flevoland of which a great deal was retrieved from the shipwreck archive (primary dataset). The third exploited dataset is the national archaeological database ARCHIS. Using specific search terms (*e.g.* 'ESCH' as the complex type for shipwrecks), relevant data could be filtered from the massive number of overall data.

It is thought that at least 400 shipwrecks have been examined by archaeologists in the Zuyder Zee region, but the exact numbers differ for each of the datasets. Research by Van Popta (2012a) proved that information on shipwrecks from both the Ship Catalog and ARCHIS contains a large number of errors. The most commonly made mistakes are duplicated wreck notifications and contradictory information on specific wrecks. As a consequence, the 459 shipwrecks in ARCHIS and the 471 wrecks in the Ship Catalog were reduced to 423 wrecks (Van Popta 2012a: 98). In 2015, new research was conducted by the consultancy organization Periplus Archeomare (under the authority of the Nieuw Land Erfgoedcentrum, now part of Stichting Erfgoedpark Batavialand), in which it was tested whether known wreck sites and wreck remains could be detected by means of remote sensing (Muis & Van den Brenk 2015: 5). Side-scan sonar data, LiDAR-data (Airborne Light Detection and Ranging), historical aerial photographs and satellite images were combined and analysed. The outcomes were added to the SDF, mainly concerning (1) structures visible on LiDAR-images and historical aerial photographs and (2) whether shipwrecks were still present at wreck sites or not. It was concluded that locating wreck sites with the help of historical aerial photographs is harder than expected. Several causes were given: the resolution of the photographs was too low, wreck sites could not be distinguished from other phenomena such as tree stumps, and wreck sites could not be detected due to soil disturbance (*e.g.* ploughing) and vegetation cover (Muis & Van den Brenk 2015: 47). Based on the analysis of Periplus Archeomare, 23 wreck sites were added to the SDF and another 12 wreck sites were given new and more accurate coordinates.

Approach

The current analysis of wreck locations in the province of Flevoland is based on the previous version of the SDF (2.0; 2015) and uses a more detailed approach than the one conducted by Periplus Archeomare. The database (MS-Access) was connected to the Geographical Information System ArcGIS, so wreck locations could be visualized in a spatial environment, thus providing the opportunity to connect them with other spatial input. The most important ones are the Dutch LiDAR-model 'AHN' (*Actueel Hoogtebestand Nederland*; version 2), 25 cm-resolution satellite images of 2016 (available via ArcGIS-online), and a complete set of historical aerial photographs of the province of Flevoland.[3] The LiDAR-data of the AHN 2 has a resolution of 6 to 10 points per m^2 and the possibility to make grid cells of 50 x 50 cm (Van der Zon 2013: 6). In ArcGIS, the LiDAR-data was transformed into a Digital Elevation Model (DEM) for the whole region, in which ground-covered, pit-stored, removed and possibly present shipwrecks can be visualized as small hills or depressions in the land.[4] Modern satellite images (2016) reveal no wreck sites, except for the ones that are ground-covered or pit-stored (*in situ* preservation methods) in Southern Flevoland, but the images are of importance for orienting and georeferencing historical aerial photographs and relocating wreck sites that lack proper coordinates.

The historical aerial photographs of Flevoland provide a detailed and chronological overview of the development of the different parts of the province. The Noordoostpolder is the oldest polder and therefore has the largest collection of aerial photographs: 1947, 1949, 1960, 1971, 1981, 1989, 2000, 2003 and 2006. Aerial photographs of Eastern Flevoland are available from 1960 onwards as the reclamation of the region was finished in 1957. The aerial photographs for Southern Flevoland are limited to the period of 1971–2006 as the region was reclaimed in 1968. Especially the combination of historical aerial photographs and the information of the shipwreck archive of Flevoland turned out to be fruitful for discovering the locations of wreck sites.

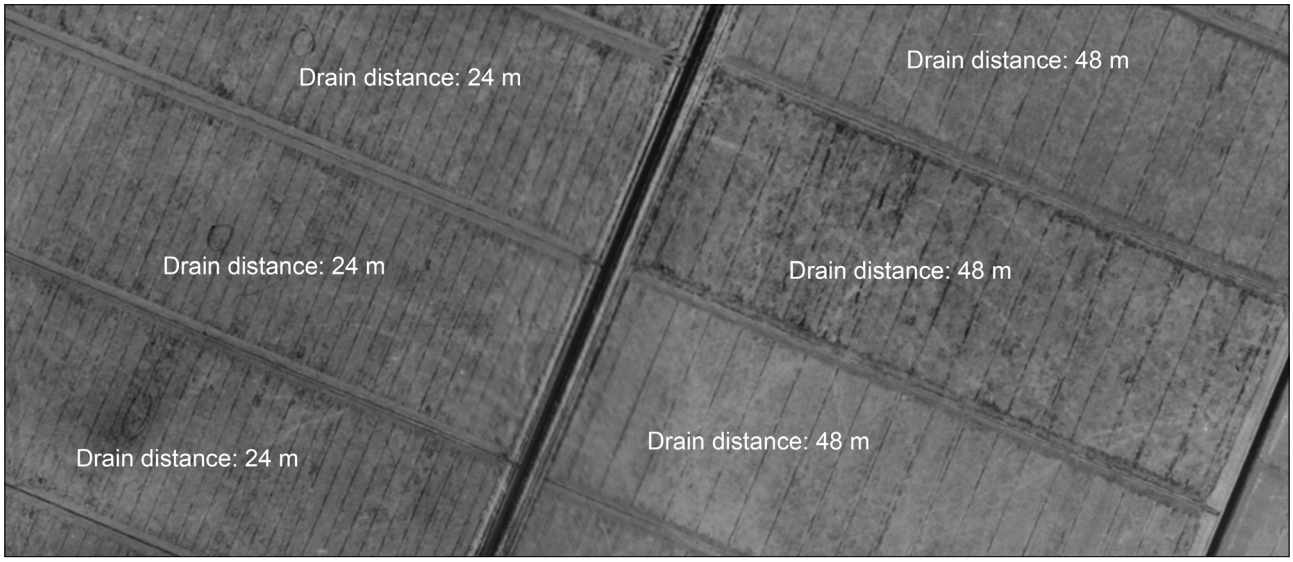


Figure 5.2. An example of different drainage systems in adjacent lots in Eastern Flevoland in 1960: the distance between two drains is 24 m on the left and 48m on the right (aerial photograph: Province of Flevoland).

The locations of the oldest known shipwrecks (collected in the 1940s and 1950s) are solely described in the same exact way, as is demonstrated by the following example:

"the wreck is positioned between the … (number) and … (number) drain ditch from the main watercourse (*tocht*) and is situated at approximately … (number) meters from the ditch (*sloot*) that separates … (lot number) from … (lot number)".

The distance between such a wreck site and such a ditch that separates two lots can be measured easily in the GIS based on satellite images. However, the distance from the main watercourse to the shipwreck, based on the number of intervening drain ditches, is problematic for several reasons. First of all, the description of wreck sites in the shipwreck archive always refers to the old network of drains and drainage ditches. These ceramic drains have since been replaced by a different system of synthetic drains, making the old system invisible and untraceable, because in many cases the old system is obsolete and as such not visible anymore in the field. The second problematic factor is the variable distance between two drain ditches: in general the interval between drains varied from 8-16 m in the Noordoostpolder and 24-48 m in the other parts of Flevoland. The system is however not standardized and old aerial photographs show a lot of variation in the distance between drains (even within the borders of a lot), especially in the eastern and southern part of Flevoland (Fig. 5.2). It is therefore not possible to multiply the number of drains with an average interval distance in order to retrieve the distance from the main watercourse to the wreck location. However, the oldest aerial photographs for each of the regions depict the newly reclaimed and cultivated soils, not yet disturbed by ploughing, with the old drainage systems in most cases clearly visible as soil or crop marks. For the Noordoostpolder region, the aerial photographs of 1949 turned out to be most suitable, while the aerial photographs of 1960 were best for Eastern Flevoland and those from 1971 for Southern Flevoland.

The first step in retrieving the distance from the main water course to the shipwreck is to precisely georeference the historical aerial photographs that depict wreck sites in ArcGIS. The location of the drain ditch that was mentioned in the documentation can then be found by counting all the ditches on the lot. This, together with the distance that was calculated from the ditch that separates two lots, leads to the exact location of the wreck site. The method is illustrated by the example of shipwreck NE 87 which, according to ARCHIS and the Ship Catalog, is located on lot NE 86, circa 250 m to the east of the Professor Brandsmaweg and 50 m north of the ditch that separates lot NE 86 from NE 87 (Fig. 5.3).

The documentation of the shipwreck suggests a completely different location for the wreck: it should be located along the 49th drain on lot NE 87 (counting from the Professor Brandsmaweg) and 90 m south from the ditch that separates lot NE 86 from NE 87. The old drainage system has likely been removed a long time ago and the 49th drain is therefore untraceable in the field and on recent satellite images. It is however clearly visible on historical aerial photographs from 1949. By georeferencing these in the GIS, it is possible to count the number of 'old' drainage ditches (visible as white lines) from the Professor Brandsmaweg towards the

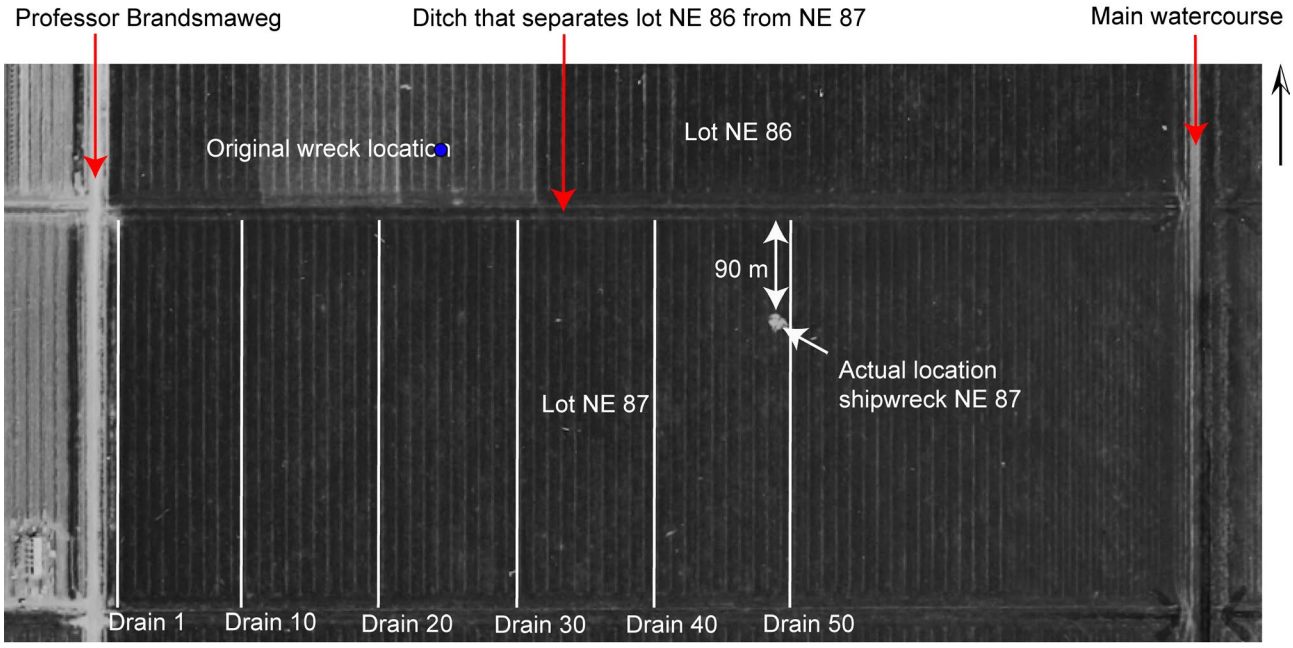


Figure 5.3. Aerial photograph from 1949; marked on it are the incorrect 'original' registered and (corrected) 'actual' wreck site locations for shipwreck NE 87 (aerial photograph: Province of Flevoland).

east, until the 49th drain is found. Then, the distance of 90 m from the NE 86 / NE 87-ditch towards the south can be measured along the 49th drain, providing the exact location of the shipwreck. Coincidentally, in this particular case the wreck site is visible on the aerial photograph as a large somewhat circular discoloration.

Not every wreck site is described in this way, however. In some cases local reference points have been used that cannot be traced anymore, like milestones/kilometer markers, changed or removed infrastructure (although these can be visible on historical aerial photographs) and mobile entities like crops and machines. In most of these cases, the description of the wreck location was intended for the archaeologists that had to examine the wreck, thus for temporary use only. In order to work with the variability of accuracy of wreck locations, it was decided to give each of the shipwrecks an accuracy score. A score of 1 means that the original wreck location in ArcGIS is the actual location of the wreck. In other words, the provided coordinates are positioned in the centre of the actual wreck location. A score of 2 means that it is likely that the shipwreck is or was located near the stated location. This goes for a wreck site description like: "the shipwreck is located in the utmost southeastern part of the lot", for which a random point in this area is chosen as the wreck location. A score of 3 means that the location of the wreck is unknown. As the name of a shipwreck in Flevoland in most cases refers to the lot on which it was found, a score of 3 indicates that it must be located somewhere on the corresponding lot, without knowing the exact location within. In those cases, center coordinates of the lot are used. Hence, if a wreck site appears to be in the center of a lot, it is important for the user of the database to check whether the accuracy score is 3, as several actual wreck sites (accuracy 1) are positioned in the center of the lot by coincidence.

Besides the accuracy of wreck sites the research has also focused on the question which shipwrecks are still present, and which ones have been removed in the past. The Ship Catalog contains a column in which information about the presence or absence of wrecks is noted, but it is unclear where this information is derived from. Especially those wrecks that are defined as 'given up' are confusing: it means that the primary information of these shipwrecks is incomplete, but not necessarily that the wrecks have been removed. Periplus Archeomare (Muis & Van den Brenk 2015) also tried to create an overview of the shipwrecks still present in Flevoland, but their data and interpretations are incomplete. Therefore, the results of a new study on the presence or absence of shipwrecks, based on the documentation in the shipwreck archive, have been added to the SDF 3.0. Especially the daily reports were of crucial importance as in many cases they mention, in the final entries of the excavation, whether a wreck was removed, shifted or covered up. Frequently encountered examples are "the timbers were disassembled and transported" (wreck removed), "the timbers were burned on the land" (wreck removed) and "the wreck was covered with cloths and the excavation pit was covered up" (wreck still present). There are however plenty of shipwrecks for which daily reports are missing, making it harder to figure out whether these wrecks were removed. In some cases, cor-

respondence between the archaeologists and the land users/tenants reveals further relevant information, as when mention is made that a wreck has been removed after inspection and/or excavation. In other cases it is only mentioned that a wreck is of little scientific importance and has been given up; it then depends on the actions of the land owner or tenant whether a wreck has been removed or not. Wrecks can also partially be present still if only the highest parts of the wreck were removed, for example when the deepest timbers were no obstacle to ploughing the land. This information can either be found in the excavation documentation or by carrying out a trial excavation. Each of the wrecks in the SDF is given a second score that indicates whether a wreck is still present or removed. When the presence or absence is uncertain, the score 'unknown' is used.

Results

The first version of the SDF (1.0, 2012) contained 423 shipwreck records, while the second version (2.0, 2015) contained 446 records after Periplus Archeomare added another 23 records to the database. The third version of the SDF, presented here, contains 449 records (for data, see: Van Popta & Van Holk, 2018). Although there appears to be a difference of only three records between the second and third versions, in fact 23 records were removed and another 26 added to the database (Table 5.1). Also, the locations of 218 wreck sites were corrected; this amounts to almost one incorrect shipwreck location for every two records and an average error of approximately 356 m for each of the adapted wreck sites. The corrections of wreck site locations can be divided in (1) records with center coordinates, (2) wreck sites that were depicted on the wrong lot, (3) wreck sites with incorrect coordinates due to typing errors, and (4) wreck sites with incorrect coordinates due to the use of estimated or random coordinates (Table 5.2).

Centre coordinates were often used to pinpoint wreck sites on regional topographical maps for those wrecks of which the actual location was not known. The

Table 5.1. Overview of the records that were removed or added to the third version of the SDF.

Removed from SDF	**Reason**
NA 23	Not a shipwreck
NA 90	Not a shipwreck
NC 35	No wreck found
ND 2	No wreck found
ND 22	No wreck found
NE 46	No wreck found
NG 62	No wreck found
NH 7	The same as NK 7
NK 12	No wreck found
NK 16/17	No wreck found
OG 158	Mentioned twice
OG 33	The same as OG 34
OK 48	The same as OH 48
ON 6	The same as ON 6-I
ON 23	The same as ON 59
OP 71	The same as OP 72
OU 112	The same as OU 113
OZ 36	The same as ZO 36
ZC3	The same as 3Z6
ZK 46	The same as ZK 45/ZK 46
ZN 3	The same as ZN 103
ZN 13	The same as ZN 113
IJH-01	The same as IJsselmeer Houtribsluizen 1
Added to SDF	**Ship type**
3Z6 De Vliegende Hollander	Unknown
Blocq van Kuffeler	Likely a Volendammer kwak
De Onderneming	Unknown

Table 5.1. Continued.

Added to SDF	Ship type
IJsselmeer Urk con-1	Fishing vessel
IJsselmeer Urk con-2	Unknown
IJsselmeer Urk con-3	Unknown
IJsselmeer Urk-roeisloep	Flatboat
James Stewartstraat Almere	Split tree trunk with metal fittings
Johanna	Unknown
Hanzerak West	Pram/tjalk
Ketelmeer West	Freighter
NC 87	Unknown
ND 86-II	Unknown
NE 103	Unknown
NE 133	Unknown
NP 32	Unknown
NP 34	Unknown
OH 49 (Beverweg)	Unknown
P.I. 65	Unknown
Vijf Gebroeders	Pram
Markermeer sonarcontact 109	Unknown
Markermeer sonarcontact 137	Tjalk
Markermeer sonarcontact 149	Unknown
Markermeer sonarcontact 31	Unknown
Markermeer sonarcontact 35	Unknown
Markermeer sonarcontact 71	Unknown

only certainty provided was the name of the shipwreck, referring to the toponym that was used for a specific lot: shipwreck NR 4 refers to Noordoostpolder (N), R-section, lot number 4. As a consequence of using center coordinates, an artificial appearance of accuracy was created, and many of these locations were adopted in national databases and never checked afterwards. Based on the new methodology, it was possible to accurately reposition 36 wreck sites with center coordinates. The smallest adjustment measured only 50 m, indicating that this shipwreck by coincidence was lying near the center of the lot. However, the majority of these wreck sites (n=20) have a deviation of 200 to 400 m. The largest adjustments came from wreck sites from the southern part of Flevoland and measured in three cases more than 800 m. This is no coincidence: it underlines the differences in size of the lots in the three regions. The lots of the Noordoostpolder and Eastern Flevoland are much smaller (10-40 ha) than those of Southern Flevoland (30-90 ha, Table 5.3). It means that, when using center coordinates for unknown wreck locations, the chance of a large deviation is bigger for the southern part of Flevoland than for the other regions. In general the deviation cannot extend beyond 900 meters as the largest lots in Southern Flevoland have a length of approximately 1800 m: in these cases the actual shipwreck should be laying at the beginning or far end of the lot, while the provided coordinates represent the center of the lot (Fig. 5.4).

The deviation of shipwrecks depicted on wrong lots is far larger than for those with center coordinates: a total of 27 wreck locations were adjusted with a total deviation of approximately 30 km (Table 5.2). A third of them has a deviation of more than one km, and there are two major exceptions: shipwreck NA 8 was depicted 5,3 km from its actual location and the coordinates of shipwreck OY 96 were positioned 6,5 km to the northwest of the actual wreck site. There is no general explanation for the errors that were made. Many of them are presumably caused by inattention and typing errors.

These errors can have a large impact on archaeological heritage management, especially in those cases when it is decided to protect a wreck site: not only would a piece of land be protected that lacks wreck remains, it would also wrongfully limit the possibilities of the landowner. A total number of six shipwrecks was misplaced merely due to errors with a total deviation of 4500 m and an average deviation of 750 m (Table 5.2).

Table 5.2. Overview of the 218 adjusted shipwreck locations, divided into deviation and distance categories. Each of the deviation categories has an average deviation (per wreck site) and overall deviation.

Category	Deviation (m)	Number
Center coordinates	0-100	1
	101-200	5
	201-300	10
	301-400	10
	401-500	4
	501-600	1
	> 600	5
	Average deviation	362
	Total deviation	13040
	Total shipwrecks	36
Wrong lot	0-200	3
	201-400	5
	401-600	3
	601-800	5
	801-1000	2
	> 1000	9
	Average deviation	1113
	Total deviation	30050
	Total shipwrecks	27
Error	0-1000	3
	1001-2000	1
	2001-3000	1
	> 3000	1
	Average deviation	750
	Total deviation	4500
	Total shipwrecks	6
Estimate/random	0-100	59
	101-200	34
	201-300	18
	301-400	16
	401-500	10
	501-600	4
	601-700	3
	701-800	3
	> 800	2
	Average deviation	199
	Total deviation	29705
	Total shipwrecks	149

Although this category corresponds closely to the wrecks that are depicted on wrong lots, an error does not necessarily mean that the shipwreck is attributed to a different lot. This is illustrated by the wrecks on lot ZA 87, of which two are switched due to a misinterpretation of the toponyms of both wrecks: ZA 87-II is positioned on the wreck site of ZA 87-III and vice versa. The total error measures 235 m for both wrecks and is within the boundaries of the lot. The shipwreck on lot OH 101 is originally also depicted in the wrong location within the boundaries of the lot due to a misinterpretation of the description of the wreck site. The actual description

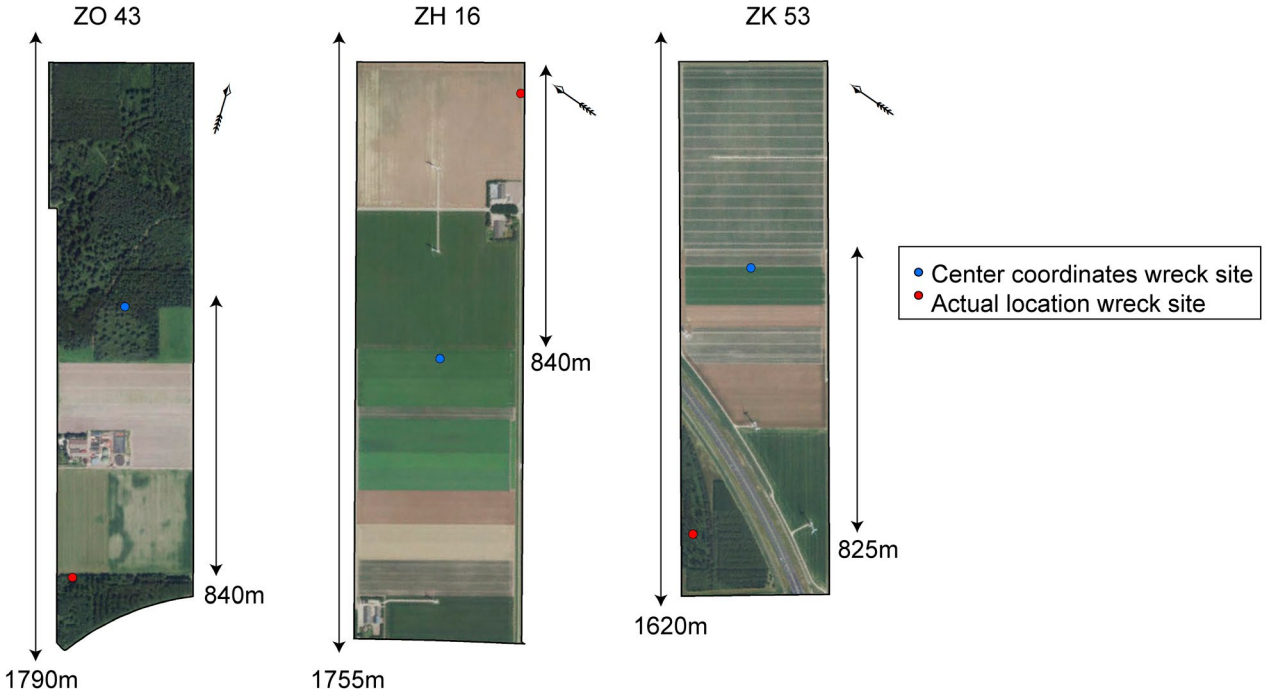


Figure 5.4. Examples of large-scale deviations, due to the use of lot-centre coordinates, between incorrect recorded locations and reconstructed actual wreck site locations in Southern Flevoland.

Table 5.3. Overview of lot sizes for different parts of the province of Flevoland.

Size lot (ha)	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	> 100
Noordoostpolder	177	412	1428	38							
Eastern Flevoland	162	417	925	221	37	4		4			
Southern Flevoland	6	24	47	84	56	71	35	44	50	8	2
Total	345	853	2400	343	93	75	35	48	50	8	2

says that the wreck is positioned at 550 m from the main water course and 25 m from the ditch that separates the lots OH 101/OH 102. Instead, the wreck is depicted at 500 m from the main water course and 25 m from the ditch on the other side of the lot, causing a deviation of 250 m (Fig. 5.5). Two other shipwreck locations (NC 51 and NA 59) have a much larger misplacement due to type errors: the X-coordinate of NC 51 is 523860 while it should be 526577, causing a difference of 2,7 km between the depicted and actual wreck site. Shipwreck NA 59 is depicted 200 km north of its actual location as the Y-coordinate was misspelled: 737040 should have been 536870.[5]

The use of random or estimated coordinates has caused the largest number of deviations of wreck sites in Flevoland. In total, 149 wreck locations have been adjusted with a total error distance of almost 30 km (Table 5.2). Looking at the deviation for each of the wreck sites, it is clear that the majority (60%) have an error of less than 200 m. A total of 32 wreck sites have seen only small adjustments (a maximum 50 m) of the wreck location, for example when coordinates were used of a fixed point in the direct proximity of the shipwreck (*e.g.* corner of excavation pit), instead of the center of the wreck itself.

The average deviation for each wreck site amounts to almost 200 m. The majority of these deviations is caused by the fact that many locations have been estimated at the beginning of the digital era, for example for the development of the national database ARCHIS. The question is why estimated or even random coordinates were used to indicate wreck locations instead of an accurate positioning. The lack of a clear approach and the availability of only very basic digital tools seem to cover one side of the explanation. Furthermore, wreck locations might have been digitalized from distribution maps on paper of which the accuracy is limited to the regional level (scale 1:50.000). In general, the wreck locations on these maps are represented by dots of which the drawn size represents already 50 to 100 m. So, the scale of the first paper maps also partially determines the accuracy of later digitized maps. However, it

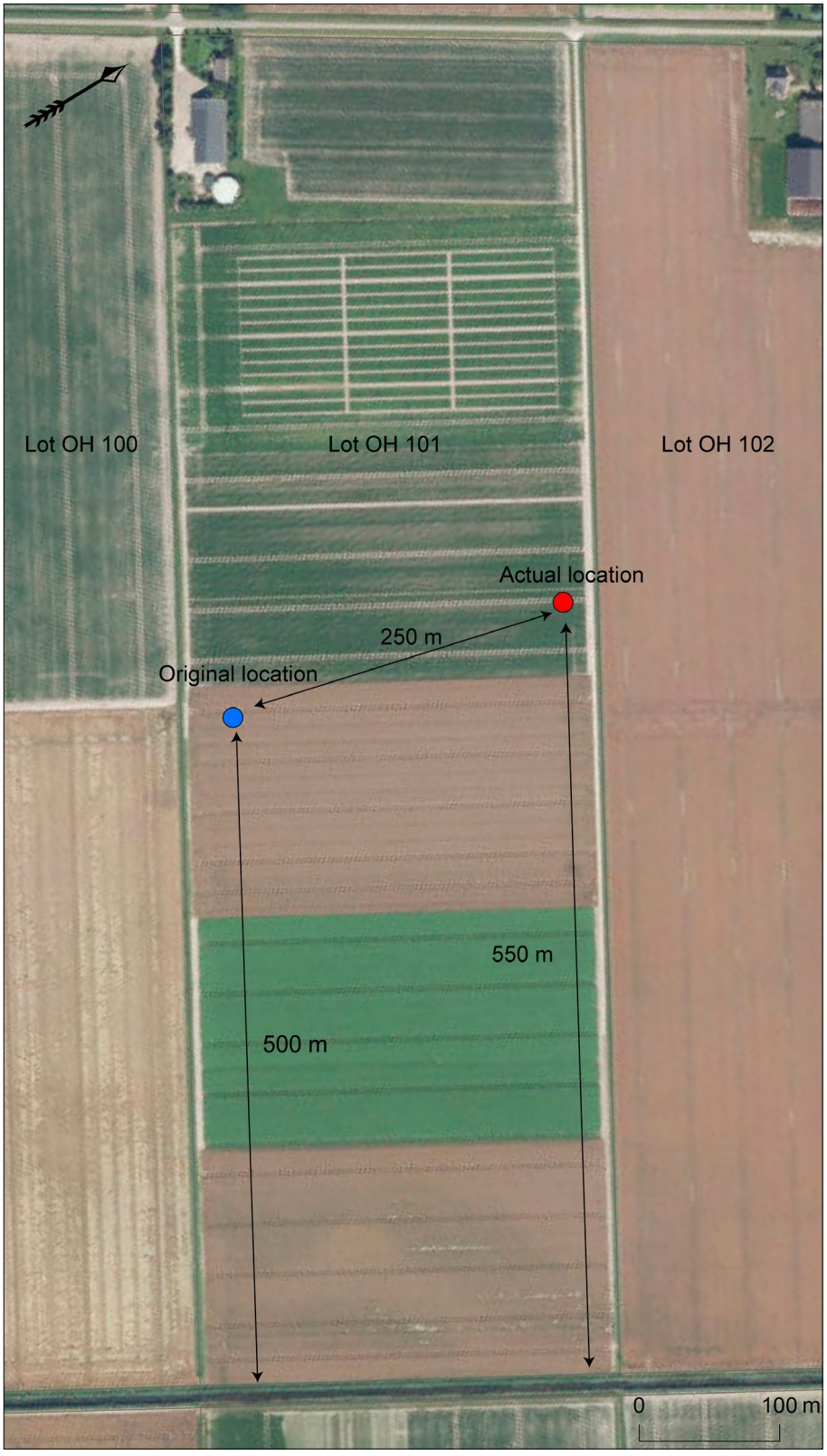


Figure 5.5. An example of a misinterpreted shipwreck location. Originally, the wreck was marked close to the ditch that separates lots OH 100 and OH 101, while it should be close to the ditch that separates lot OH 101 from lot OH 102.

does not explain why in some cases shipwrecks seem to have complete random coordinates. This can be illustrated by looking at the case of shipwreck ZM 8: the location of the wreck site is described as "183 m from the ditch that separates ZM 7 and ZM 8" and "165 m from the Roerdompweg", which should be in the northeastern part of the lot (Fig. 5.6). For some reason, the wreck location is, according to ARCHIS and the Ship Catalog, depicted in the southwestern part of the lot, 435 m from the ditch that separates ZM 7 and ZM 8, and 820 m from the Roerdompweg. The official report even provides the correct coordinates of the wreck

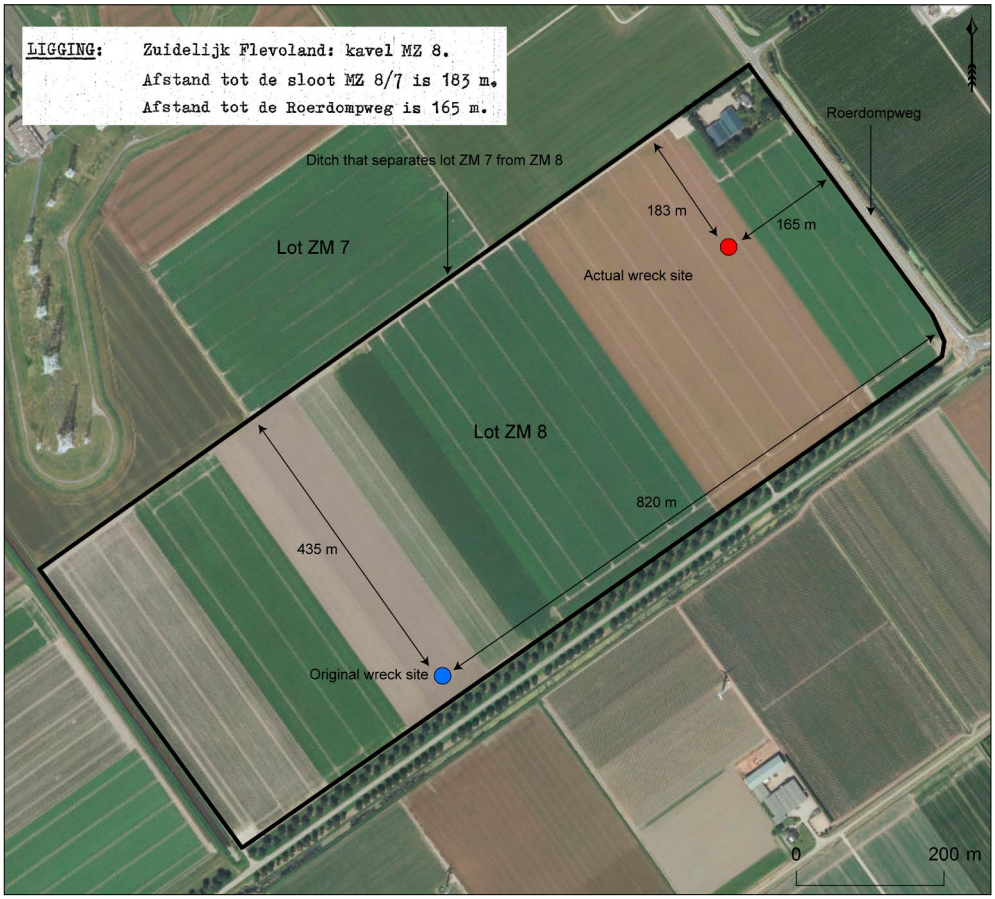


Figure 5.6. This figure shows the actual wreck site of shipwreck ZM 8 (red dot) and its recorded location (blue dot). The use of random coordinates, while an accurate wreck site description was available, caused a deviation of 700 m.

site, but they have been neglected in both databases. As a result, a deviation of 700 m existed between the depicted wreck site and the actual location of the wreck.

Wreck sites on aerial photographs and LiDAR-data

Aerial photographs were primarily useful for searching the relevant old drainage ditches that were used to mark the locations of wreck sites. Nevertheless, it turned out that the photographs have a second function, as in specific cases they depict the actual wreck sites in different ways. First of all, some aerial photographs depict shipwreck excavation pits as, by coincidence, the photographs were taken during archaeological research. At least 15 excavation pits are visible on aerial photographs, of which 6 can be seen in Figure 5.7. A thorough study of aerial photographs might even lead to more visible excavation sites (an exercise which has not been done yet). Second, wreck sites can also be visible as discolorations on aerial photographs (Fig. 5.8). Especially when the land was ploughed for the first time and no crops were planted yet. The discolorations are often caused by the disturbance of sediments near the wreck site due to (post-) depositional processes. For example, the wreckage of a ship can cause a rapid flow of water when the wreck sticks out of the seabed. As a consequence, relative large amounts of sand and shells are deposited as a thick layer of sediment next to the wreck site. After the reclamations and the first phase of land cultivation, these sandy wreck sites differ from the natural clay sediments in composition and colour and become visible under the right circumstances. All depends of course on variables like the local composition of sediments, the size and completeness of the wreck and the thickness of the sediments that cover the wreck.

The analysis of LiDAR-data, providing a height overview of the present surface of the former seabed, has proven to be ineffective when searching for wreck locations in Flevoland. One might expect that still present shipwrecks are visible as minor elevations in the land, as the soil on top and below shipwrecks (often with their keels on the Pleistocene subsoil) does not settle, while their surroundings continue to settle due to drainage. It would also mean that removed wrecks should be visible as depressions on the surface. However, fields are nowadays so intensively ploughed that small elevation differences are immediately leveled. Furthermore, former wreck site depressions have in many cases been filled with extra ground in order to keep the fields as flat as possible. It does not mean that all wreck sites are invisible: the wrecks that are ground-covered or pit-stored (most of them are from the southern part of Flevoland) are clearly visible on LiDAR-data (Fig. 5.9). As the

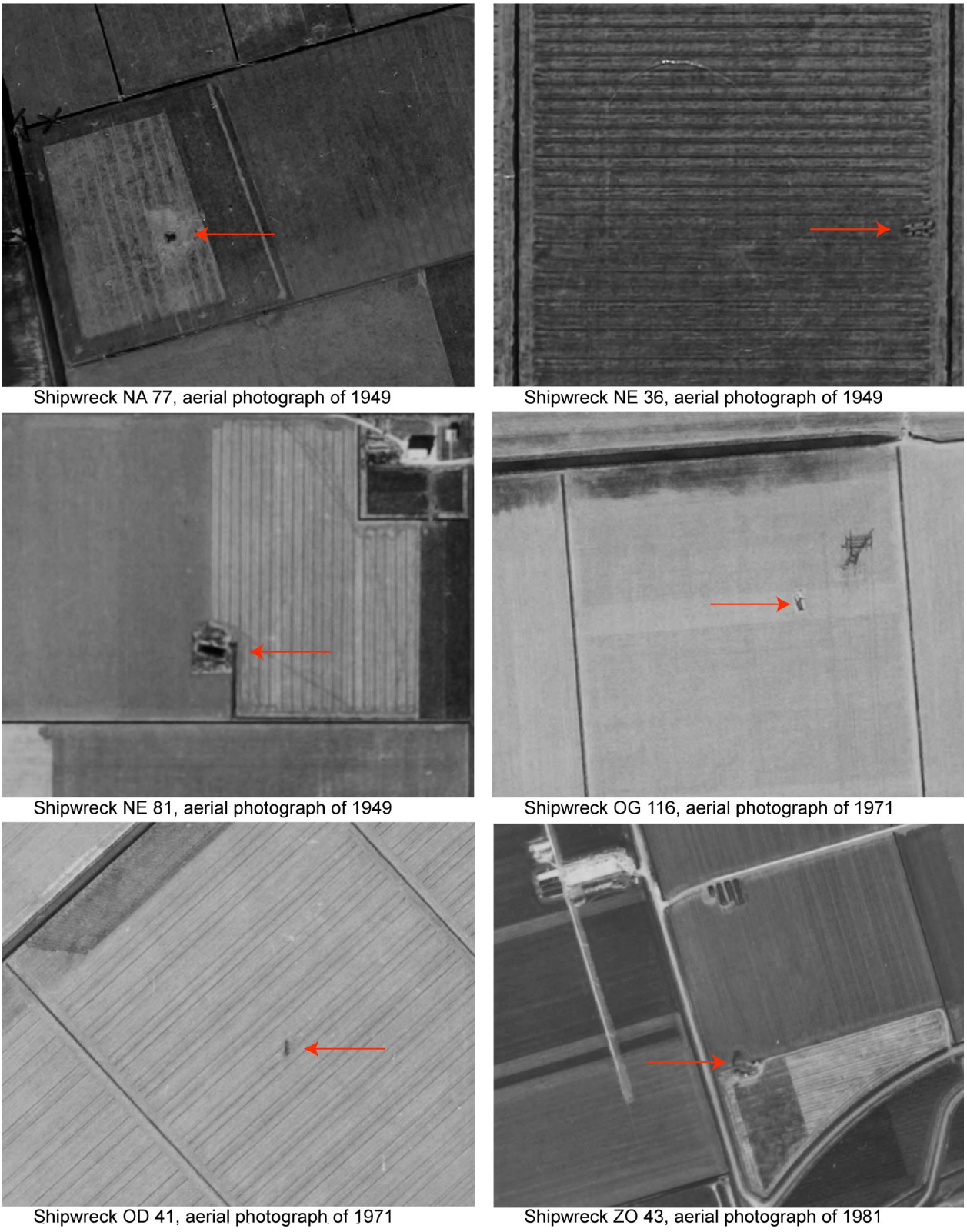
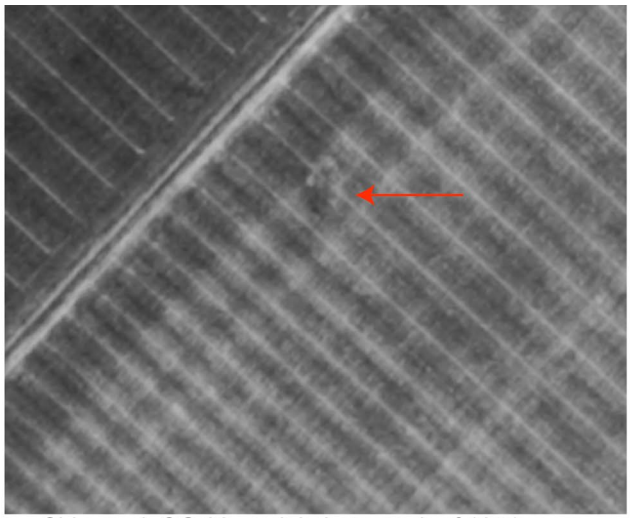


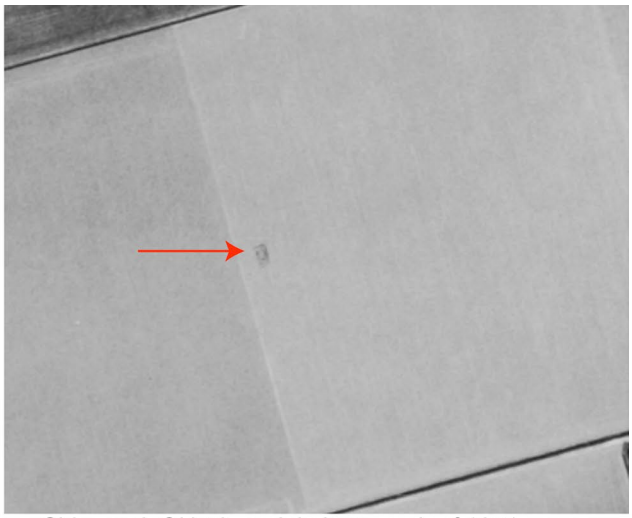
Figure 5.7. Six examples of excavation trenches that are clearly recognizable in historical aerial photographs (aerial photographs: Province of Flevoland).

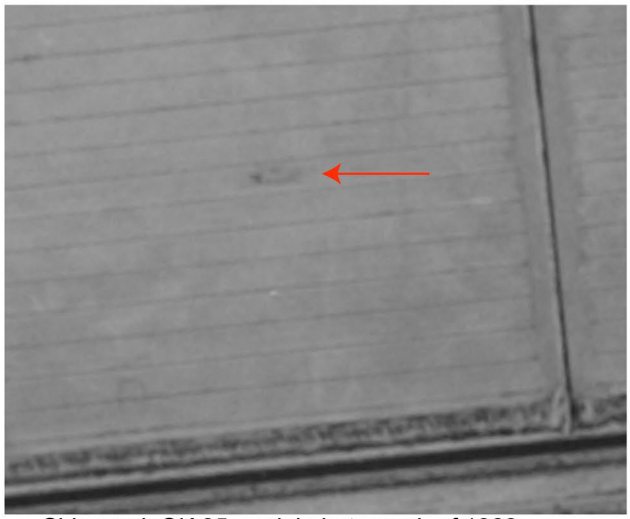
exact locations of these wreck sites are already known (recorded during the on-site conservation), LiDAR-data is only useful as a way of visualization.

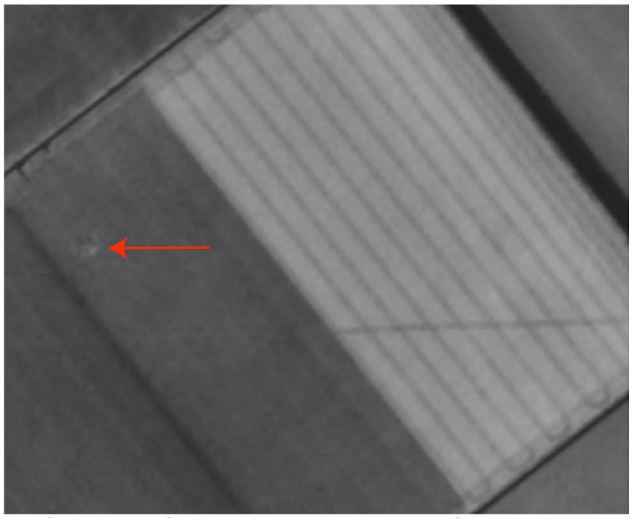
Presence and absence of shipwrecks

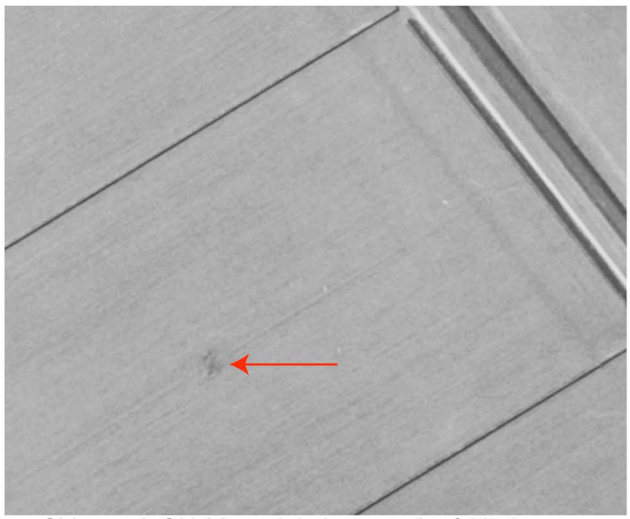
It is most important for cultural heritage management of shipwrecks in Flevoland to know the present state of


Shipwreck OG 33, aerial photograph of 1971


Shipwreck OH 48, aerial photograph of 1971


Shipwreck OK 35, aerial photograph of 1960


Shipwreck OU 34, aerial photograph of 1981


Shipwreck OU 86, aerial photograph of 1971

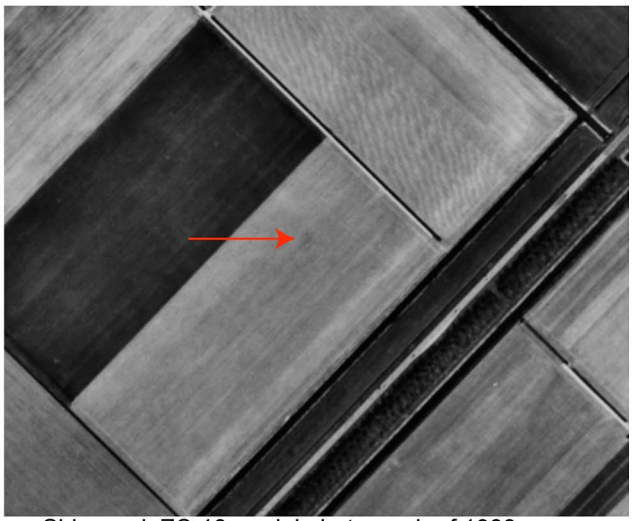

Shipwreck ZQ 18, aerial photograph of 1989

Figure 5.8. Six examples of wreck sites that can be recognized as discolorations in historical aerial photographs (aerial photographs: Province of Flevoland).

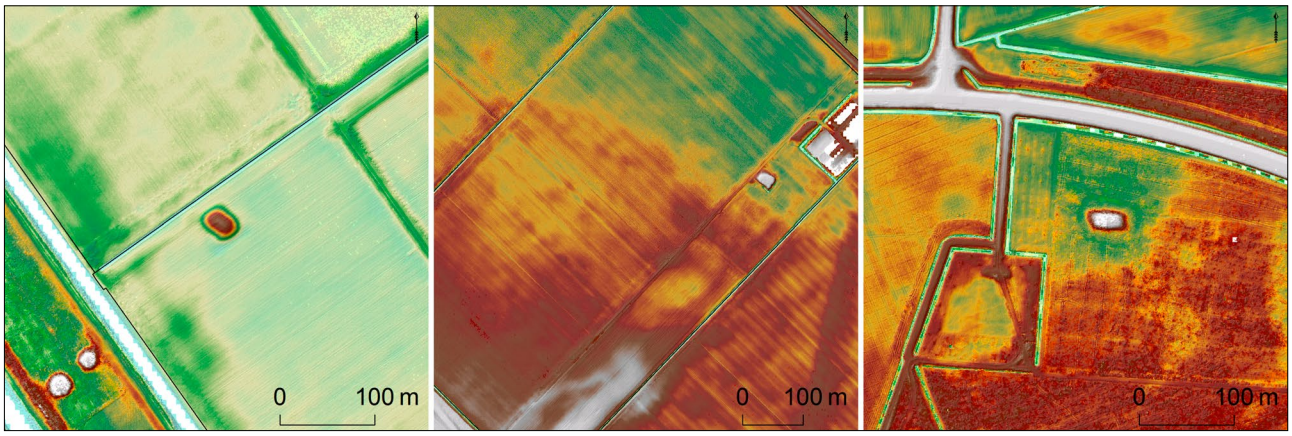


Figure 5.9. LiDAR data of three wreck sites with clearly recognizable soil-covered shipwrecks (after AHN2).

wreck sites. Those wrecks that are still present in the field should be protected (on the basis of a thorough assessment and validation of the site), while the wreck sites of already removed shipwrecks should not unnecessarily be legally protected (which does not mean that those sites cannot be commemorated by some sort of indicator). This would only create hinder for the owner and/or user of the land. Until now, a clear and complete overview of still present and removed shipwrecks in Flevoland was lacking. There were some lists with information about still present shipwrecks, but they focused largely on the most obvious ones (pit-stored and ground-covered). For the majority of the wreck sites in Flevoland the present status was unclear. For this research the documentation of the shipwreck archive was checked for relevant information on the possible removal of wreck parts. The results are as follows: at least 96 wrecks are preserved *in situ* and 271 wrecks have been removed. Of the 96 shipwrecks still present, 42 are lying in the former seabed with little or no protection, 24 wrecks are lying under water and 30 wrecks are either ground-covered or pit-stored.

There are 82 wrecks of which the present situation is uncertain. The uncertainty on their condition is mainly based on poor documentation (no daily reports, no site reports) and vague updates and notifications like 'wreck given up', 'not found during reconnaissance' and 'might be removed'. For some wrecks it is known that they have been excavated in the past, but it is not explicitly mentioned whether such a wreck has been removed afterwards. There is however an indirect way for this to find out: if a shipwreck is excavated and a detailed description is provided of the construction of the hull, it would mean that the ceiling and frames were removed (this is often mentioned). Therefore it indicates that the wreck was excavated in a destructive way, rather than aiming at preserving it *in situ*. So, even though such a report does not explicitly mention that a wreck has been removed, it is likely that the timbers have been removed, transported and deselected. If in any case a shipwreck has not been found during a reconnaissance and no further details are provided, the present situation of the wreck has been set to 'unknown'.

It is important to keep in mind that, if a shipwreck has been removed, it should not mean that this wreck site is archaeologically written-off. Maritime archaeologists focus mainly on the shipwreck itself, meaning the largest number of connected timbers. Loosely connected parts of the ship (rudder, mast, rigging, leeboards, deck construction) are often separated from a ship in the wreckage process and are rarely found during excavation. Even a whole side of the ship can drift away as soon as the ships' transverse construction elements break down. Therefore, limiting the research to the main wreck site can result in overlooking other wreck parts in the vicinity of a shipwreck. This can be illustrated by looking at the excavations of shipwrecks in Flevoland by the International Fieldschool for Maritime Archaeology Flevoland (IFMAF). In the summer of 2011 and 2012, a late 16th-century freighter (OE 34) was excavated near Lelystad (Van Holk 2017b). Preceding the excavation, a short geophysical research was carried out to test whether or not wreck parts would be visible on the maps that were generated from the geophysical data. As the results came in late, it turned out that several anomalies (parts of the wreck) were located outside the excavation pit (this is also caused by the fact that the excavation pit is kept as small as possible, to minimalize disturbance of land put to agrarian use). More or less the same thing happened during the excavation of the 17th century shipwreck OR 49 in 2015. At the end of the excavation campaign, the immediate surroundings of the excavation pit were examined with a metal detector. A strong signal was picked up close to one of the edges of the excavation pit and it was decided to excavate that area as well. It turned out that the signal was coming

Figure 5.10. The largely intact and well-preserved rudder of shipwreck OR 49 that was discovered outside the excavation trench.

from metal fittings and pintles (*roerhaak*) that were part of the largely intact rudder of the ship (Fig. 5.10).

Rudders are not often found as they easily get detached from ships during the process of sinking. This specific rudder also got disconnected from the ship but was deposited quite close to the wreck. If the archaeological research would have been limited to the excavation pit, this rare and relevant part of the ship would not have been found. Furthermore, it is likely that objects from the ships' inventory have been taken by the waves during wreckage and therefore are spread around the wreck site. The most obvious way to illustrate this is by looking at the eroded and disturbed sediments (*verspoelingslaag*) that surround shipwrecks: they often contain all kinds of objects belonging to the artifactual inventory of the shipwreck. This was also observed during the IFMAF-campaigns when dozens of objects were found outside and even partially underneath the wrecks. The main point is that even if the documentation mentions that a shipwreck has been removed after archaeological research, there is a chance that construction parts and objects belonging to the artifactual inventory of the shipwreck still remain in the vicinity of the wreck. Therefore, shipwrecks that are registered as 'removed' should be interpreted as: "the shipwreck is removed, but this is still a wreck site". So from a management point of view we should pay attention to these sites too. Distinction could be made between sites that have been excavated and afterwards left alone and sites that have been destroyed.

Discussion and comparison

This research is a further step in creating a more reliable dataset of shipwrecks in Flevoland, but the end has not yet been reached. There are still plenty of wreck sites of which primary information is (partially) missing. First of all, the exact location of 260 wrecks is now known, but there are still 90 wrecks of which the wreck site is estimated and 99 wrecks of which the location is completely unknown. Second, the present situation of wreck sites is still partially unclear: 96 wrecks are preserved *in situ* and 271 have been removed in the past, but this means that it is uncertain whether the remaining 82 wrecks are still present or have been removed. Archaeological fieldwork would be useful to improve the data even further by focusing on unknown and estimated wreck locations and the shipwrecks of which the present situation is unknown. The sites in question might have been deselected for various reasons in the past, but the reasons for deselection have been changed dramatically over the years, which legitimates renewed investment. The information from both categories (accuracy and presence-absence) can also be combined in order to select the shipwrecks that should be given priority (Table 5.4).

Shipwrecks from the categories A1 and C1 need no further attention as their locations are accurate and their present status (present or absent) is known. The wrecks belonging to the categories C2 and C3 are also of less importance (with the restriction, mentioned earlier, that the surroundings of the excavation pit might contain archaeological remains) as these wrecks already have been removed, although it would be useful if accurate wreck site locations were to be retrieved eventually.

The 82 wrecks that belong to the categories B1, B2 and B3 need to be examined more closely in order to find out whether the wrecks have been removed or are still present. Special attention should be given to the 32 wrecks that belong to category B3 as both their location accuracy and present situation are unclear. High priority should also be given to the two wrecks of category A3 that are still present, but of which the exact location is unknown. Both wrecks lie within the nature reserve Oostvaardersplassen and are presumably preserved under water. As ploughing and soil disturbance is not allowed in the region, the preservation conditions of both wrecks should be good, more so because the water saturated timbers are hardly affected by oxygen (although this should be checked in the field). So, although both wrecks are not threatened at the moment, this situation can change overnight. Moreover for monitoring purposes an exact location is also necessary.

Improving the quality of the SDF by creating a higher accuracy of wreck locations and making an inventory of still present shipwrecks suits not only scientific pur-

Table 5.4. Classification of shipwrecks based on the two main factors for maritime archaeological heritage management: presence or absence, and accuracy of wreck location.

Category	Presence or absence shipwreck	Accuracy wreck location	Number of wrecks
A1	Present (A)	Exact (1)	89
B1	Unknown (B)	Exact (1)	**26**
C1	Absent (C)	Exact (1)	140
A2	Present (A)	Estimated (2)	0
B2	Unknown (B)	Estimated (2)	**24**
C2	Absent (C)	Estimated (2)	67
A3	Present (A)	Unknown (3)	**2**
B3	Unknown (B)	Unknown (3)	**32**
C3	Absent (C)	Unknown (3)	70

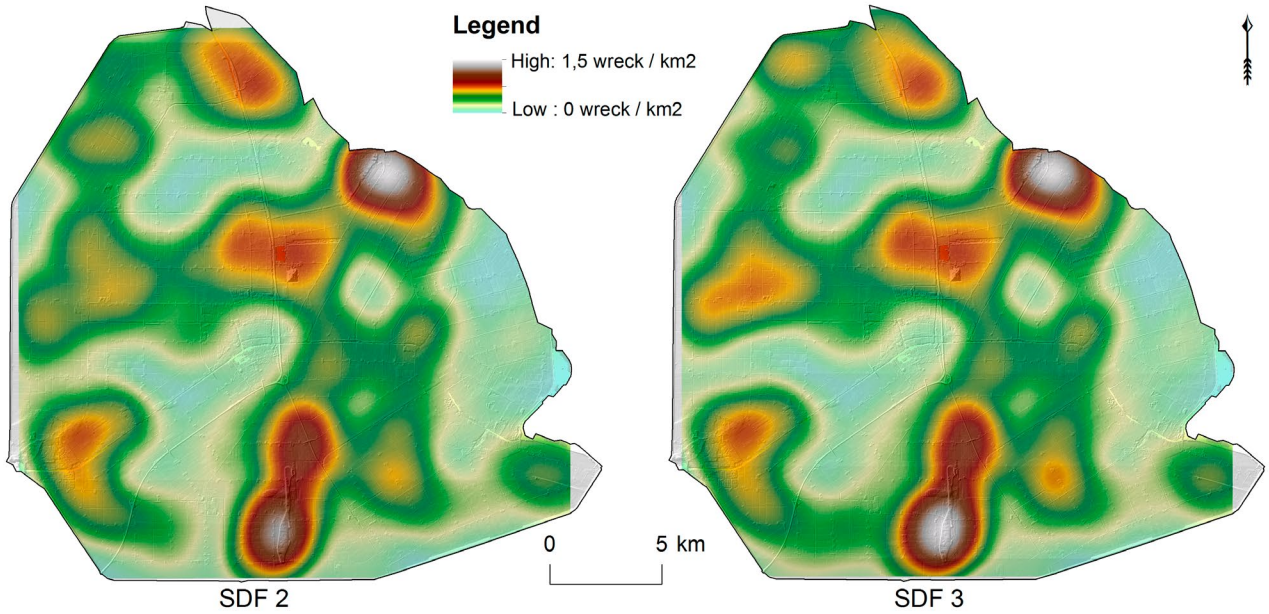


Figure 5.11. Density analysis (kernel density) of wreck sites in the Noordoostpolder, based on the SDF 2 (2012) and SDF 3.

poses but also archaeological heritage management. It results in more accurate distribution- and density maps of shipwrecks (scientific purposes) and helps in protecting the remaining shipwrecks in the right way (heritage management). For a regional and spatial wreck analysis it is important to keep in mind that the wreckage of a ship, for example due to a leak or a heavy storm, can take place at a random location, notwithstanding that some wreck locations could be more or less likely. On the other hand ships can wreck initially at a certain location and end up on the seabed at a different location, for example miles away. An average wreck location deviation of 200 m will therefore not change the general overview and interpretations of a regional spatial analysis. This can be demonstrated by comparing the old and new density- and distribution maps of shipwrecks, derived from the oldest and newest version of the SDF (Fig. 5.11).

The new density map has not changed much, although several high density areas are smaller or changed form. The spatial differences between the old (blue dots) and new (red dots) shipwreck locations are however clearly visible on the distribution map (Fig. 5.12). These differences are of particular importance for research on a local scale, for example when new archaeological finds are connected to known shipwreck sites, or when historical information about wreck sites (often given in latitude/longitude with Amsterdam as the prime median) is related to actual wreck sites. Furthermore, new results derived from distribution and density analyses might help to predict (on a regional scale) wreck locations in parts of the Zuyder Zee

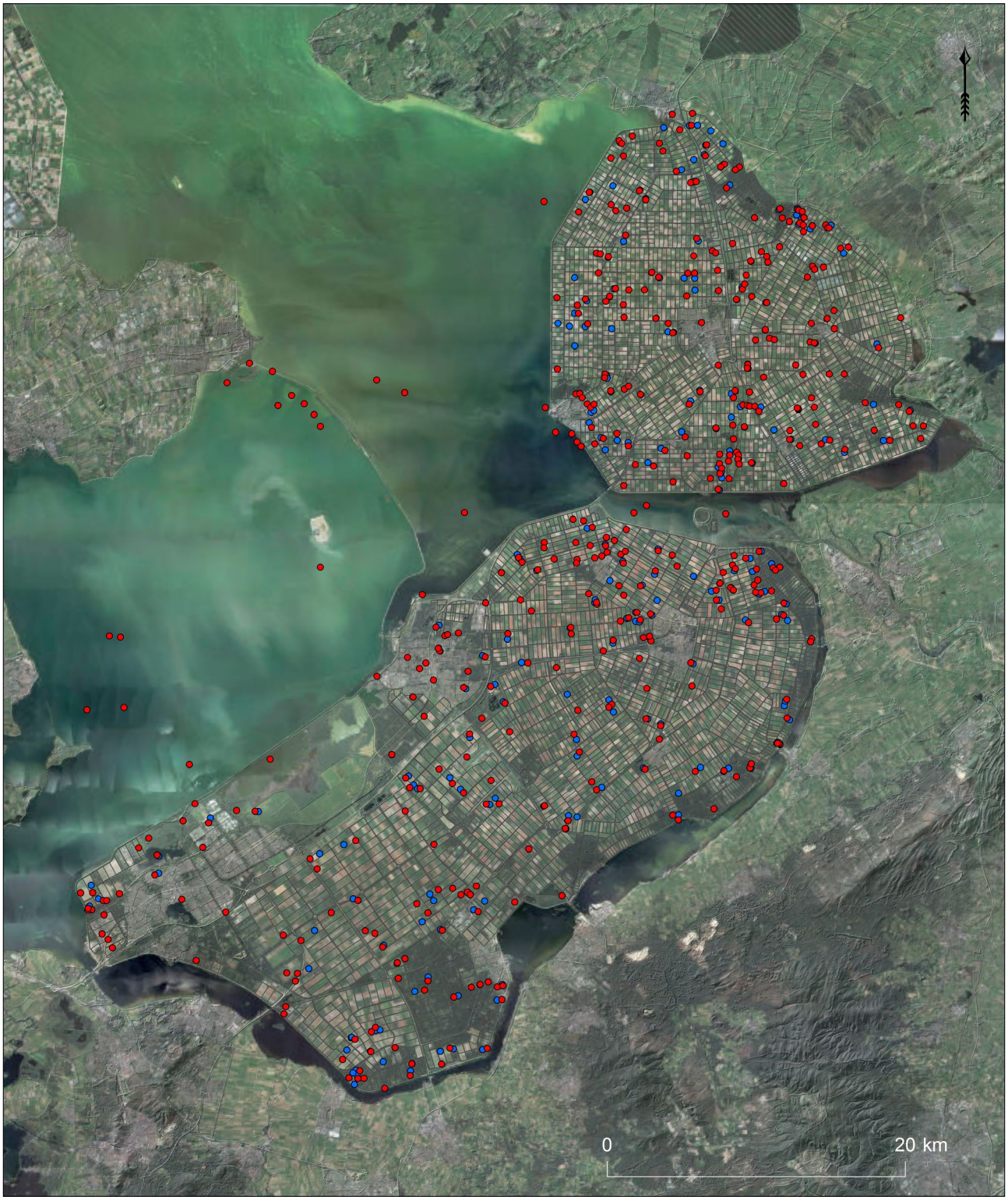


Figure 5.12. Distribution map of shipwrecks in Flevoland. The blue dots represent wreck sites of the SDF 2 that proved incorrect or spurious, the red dots represent the wreck locations of the SDF 3.

region that have not yet been thoroughly examined (*e.g.* Markermeer and IJsselmeer).

The new results are also of particular importance for maritime archaeological heritage management in three ways. First of all, the wrecks that are preserved *in situ*, of which the actual location is known, should receive the highest degree of protection (category A1). Second, the wrecks that have been removed with certainty (categories C1, C2 and C3) need no further protection, unless new wreck parts are found in the vicinity of the wreck location. The unnecessary protection of the site of removed shipwrecks would only be troublesome for the

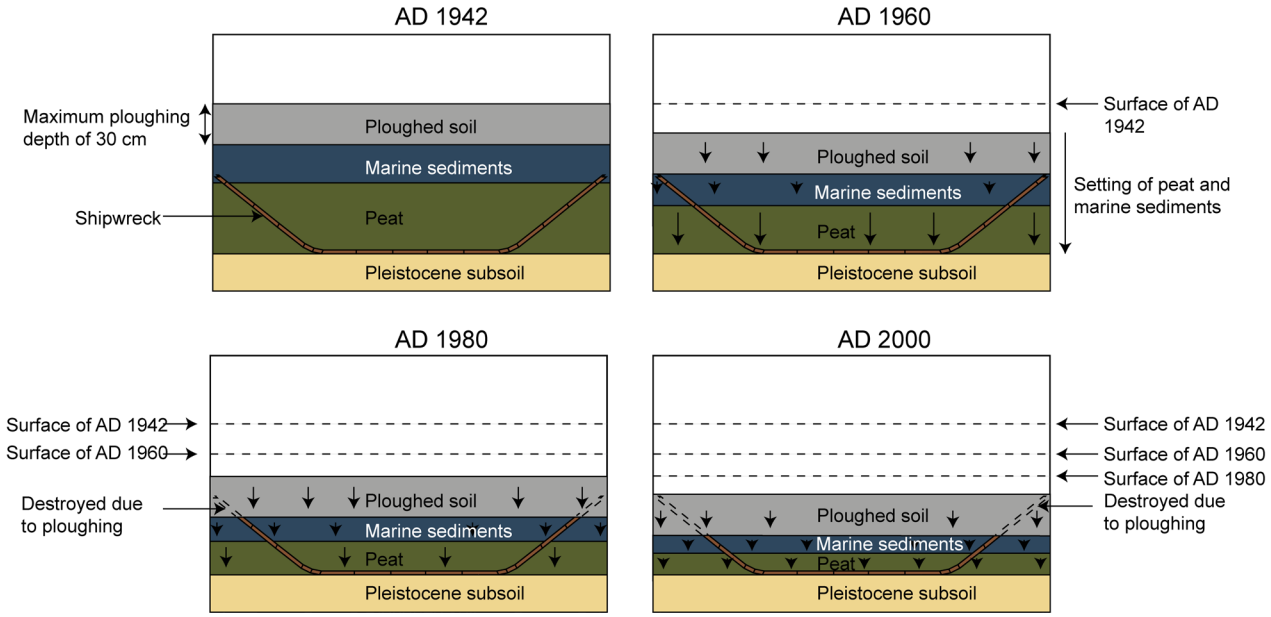


Figure 5.13. Simplified model of the effects of land subsidence and the gradual destruction of shipwrecks.

landowners. The wrecks of which the present situation is unknown and the location is exact or estimated (categories B1 and B2) should have minor protection until more details are available by archaeological reconnaissance. The (possibly) present shipwrecks of which the location is completely unknown (categories A3 and B3) cannot be treated by any kind of heritage management as it is too problematic for the users of the land (mostly farmers) to protect a complete lot. These advices have already been adopted by the archaeological firm RAAP Archaeological Consultancy while developing a new archaeological (policy) map of the Noordoostpolder municipality (Ten Anscher *et al.* 2017).[6]

They advised to protect the wreck locations of category A1 with a protective buffer of 50 m and the wrecks from categories B1 and B2 with a buffer of 100 m as the location is not exactly known (Ten Anscher *et al.* 2017: 71). Within this buffer, soil disturbance at a depth of more than 30 cm is only allowed when a permit is granted. However, one should keep in mind that a maximum ploughing depth of 30 cm is only a limited and partially inadequate way of protecting shipwrecks. Land subsidence of the former seabed will continue in the coming years, while the shipwrecks stay at the same depth, causing them to come closer to the surface (see: Van Tuinen & Van den Bersselaar 2005; De Lange *et al.* 2012).[7] As soon as the top of wreck reaches the ploughing zone due to land subsidence, every year a couple of centimeters of the top of the wreck will be destroyed by ploughing (Fig. 5.13). In most cases, the land user will not even notice that a shipwreck is being destroyed, as the highest parts of the shipwreck already are in a poor condition (oxygen can reach the wreck parts closest to the surface) and will pulverize after being hit by a plough. This theory is founded on evidence collected in the field: during shipwreck excavations in the province of Flevoland, the level of the highest parts of the shipwreck corresponded exactly with the maximum depth of the ploughing zone (Fig. 5.14). If no action is undertaken, a substantial part of the *in situ* 'preserved' shipwrecks will suffer from yearly erosion until whole wrecks are destroyed.

The results of the study on the location and presence-absence of shipwrecks in Flevoland can also be compared with the research of Periplus Archeomare (Muis & Van den Brenk 2015). Their research focused on the question whether known and unknown shipwrecks and wreck remains in Flevoland can be traced by remote sensing. Therefore, they used practically the same data as we did: historical aerial photographs from 1947-2006, LiDAR-data (AHN 2) and modern satellite images. In their conclusions they stated that finding wreck sites and shipwrecks by studying historical aerial photographs turned out to be harder than expected for three reasons. First of all, they presumed that wreck sites were most clearly visible just after the reclamations and before the former seabed was disturbed by ploughing and vegetation growth. The latter is according to them also responsible for making the landscape harder to interpret. Furthermore, the resolution of the aerial photographs was considered not to be high enough for spotting wreck sites. Last, as mentioned earlier, they stated that large parts of the former seabed contain other phenomena like tree stumps that cannot easily be distinguished from shipwrecks (Muis & Van den Brenk 2015: 47).

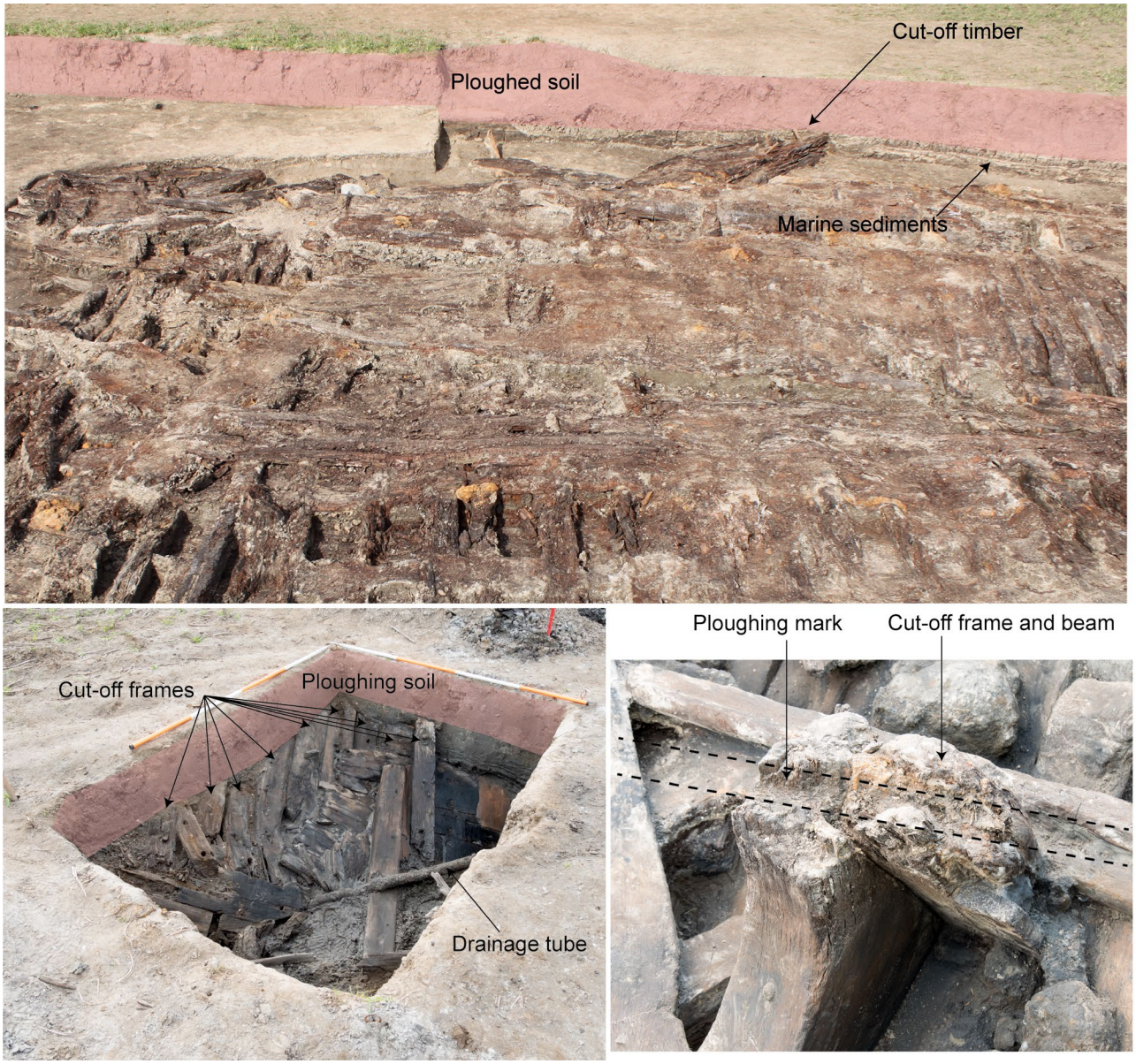


Figure 5.14. Examples of shipwrecks excavated in the province of Flevoland, parts of which have been destroyed by ploughing. The maximum depth of the plough soil corresponds to the cut-off wreck parts.

Then, for each of the wreck sites in Flevoland they described what could be seen on the oldest aerial photographs. This resulted in 7 possible objects (shipwrecks NA 57, NE 131, NE 157, NO 28, NQ 75, NT 57 and ZQ 48/49), 24 possible anchor trails and 415 wreck sites with insufficient evidence for the presence of a shipwreck (ploughed, disturbed, no traces, ditch, under water, no data). The analysis of the second dataset (LiDAR) also resulted in very limited evidence for visible wreck sites. The only wrecks that could be recognized were those that are pit-stored or ground-covered. It was noticed by Muis & Van den Brenk (2015: 36) that the coordinates of some of these specific wreck sites do not match the actual wreck location. Therefore, they recommended checking the locations of other wreck sites as well. This has not been done in their remote sensing research, despite their own warning. The present research has proven that half of the original wreck locations have a relative large deviation of at least 100–200 m. It means that 50% of the outcomes of the remote sensing analyses of Periplus Archeomare are based on incorrect and inaccurate wreck locations. A substantial part of the other 50% of the wrecks consists of wreck sites with artificial center coordinates of the lot, which makes the majority of their remote sensing analyses unfortunately unusable. The current research has proven that by checking the correct wreck locations, it is possible to recognize wreck sites on historical aerial photographs, either as a disturbance/discoloration in the field or as an excavation pit (photographed by coincidence).

Concluding remarks

The third and newest version of the Shipwreck Database Flevoland has provided a lot of new and detailed information on the present status of shipwrecks in the Zuyder Zee region (preserved *in situ*, unknown, removed) and the accuracy of the locations of these shipwrecks. Using the documentation from the shipwreck archive and several remote sensing techniques, it became clear that the locations of 218 shipwrecks had to be adapted. The total deviation amounts up to 77 km and the average deviation for each of the originally incorrect wreck sites is approximately 356 m. Most of the deviations were caused by the use of random and estimated coordinates: the only thing that really mattered was that each ship was placed on the right lot. A total of 27 wrecks was nevertheless depicted on the wrong lot. Other deviations were caused by type errors and the usage of centre coordinates of a lot. Due to the adjustments, the new version of the SDF contains 260 shipwreck records of which the exact wreck location is known. However, there are still 90 wrecks of which the location is estimated and 99 wrecks of which the location remains unknown: more work needs to be done in order to retrieve the exact locations of these wrecks as well. Examining the original excavation documentation also made it possible to present a list of preserved and removed shipwrecks. Until now, there was no clear overview of which of the Zuyder Zee wrecks are still *in situ*. It turned out that at least 96 wrecks are still present in the seabed of the former Zuyder Zee. This is a minimum number as there are 82 wrecks of which the present situation is unclear due to vague, incomplete or absent information. For 271 shipwrecks there is sufficient evidence to conclude that they have been removed from the former seabed.

The results of this research and the new version of the SDF provide a more reliable dataset for further scientific research. The large scale deviations of wreck locations and the new adjustments have no large consequences for spatial research on a regional scale, but one should keep in mind that solid spatial research, especially on a local scale, is only possible if the distribution pattern of shipwrecks is accurate and well-founded. The deviations will have consequences for archaeological research on a local scale, especially when studies are made of specific wreck sites in combination with archaeological, historical and geographical data. Furthermore, the current version of the SDF can be used for new archaeological heritage management within the Zuyder Zee region for the rightful protection of those shipwrecks that need to be protected. However, it should be realized that this rich maritime dataset is not of unlimited proportions. Most of the 96 wrecks that are still present in the former seabed, are in a process of constant degradation that will not be stopped by 'protecting' the wrecks with a maximum ploughing depth of 30 cm. New plans should be made to carefully protect these wrecks (after validation), as they are highly valuable for understanding the maritime history of the Netherlands.

To conclude, the third version of the SDF will most certainly not be the final version of the database, as there is still a lot of information that needs to be added to the database. First of all, the remaining wreck sites with partially unknown data about the present situation or wreck location should be examined more closely. Then, future research should also focus on other categories like 'ship type' and 'moment of wreckage' should be updated as well as improved. For now, the SDF 3 provides a largely improved and more detailed overview of the shipwrecks of the former Zuyder Zee that can be used by scientists as well as policymakers.

Endnotes

1 The X- and Y-coordinates of the wreck sites are screened in order to protect the wreck sites and are only available on request by contacting the Groningen Institute of Archaeology.

2 No figures are given for the expected total amount of shipwrecks in Flevoland, because that is not the topic of this contribution. On the basis of previous research by Van Popta (2012b) we can estimate the maximum amount of shipwrecks that have not been found until this day at about 90 wrecks (Van Popta 2012b).

3 The historical aerial photographs were derived from the website www.historische-luchtfoto.flevoland.nl and manually georeferenced in ArcGIS.

4 Someno shipwrecks have been preserved in situ after archaeological research by either pit-storage (inkuilen) or ground-coverage. In both cases, the shipwreck is covered by ground, but in the case of pit-coverage an artificial groundwater level is created by using large pieces of plastic to cover the ship and its immediate surroundings, except for a small opening for rainwater at the top.

5 The 200 km deviation of shipwreck NA 59 (due to a type error, at least of the first number (7), while the other errors might be the result of a mistake in the calculation of the coordinate) is neglected in the calculations of average and total deviation as it would create a large bias.

6 In addition, the archaeological firm ADC Archeoprojecten is currently using the content of the SDF 3 for heritage management aspects, as an actualization of the Archaeological Monuments Map of the province of Flevoland is needed.

7 'Ripening' of the soils in the freshly laid dry Zuyder Zee floor amounted for many decimeters of surface lowering in the period 1940-2000, its rates have since decreased but are still 1-3 mm per year (e.g. Bodemdaling.nl).